IEEE Cascading Failures Task Force (CFTF)

Task Force: Understanding, Prediction, Mitigation and Restoration of Cascading Failures

IEEE PES Computer and Analytical Methods Subcommittee (CAMS)

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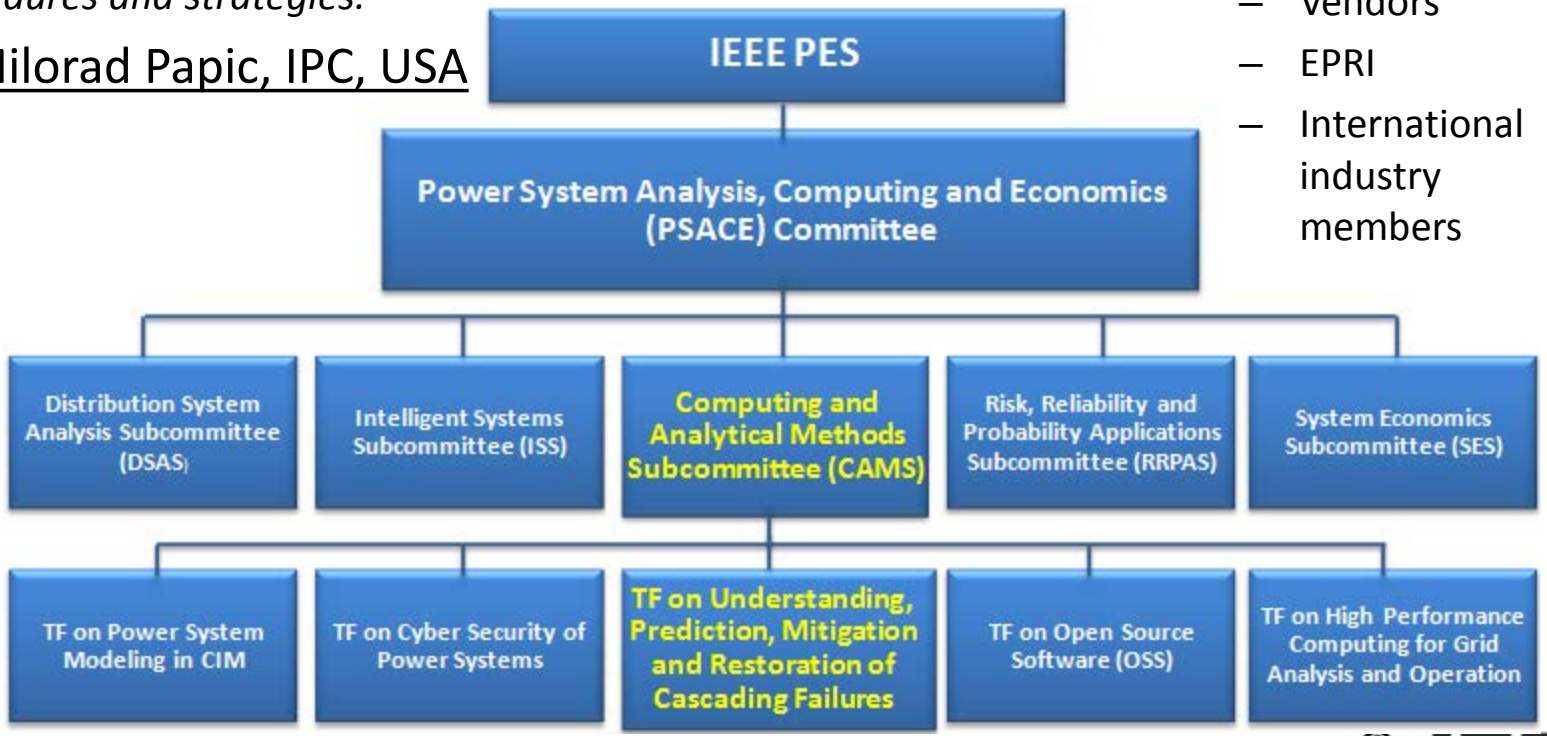
NASPI Meeting · February 21, 2013
Huntington Beach, CA

IEEE CAMS TF on Cascading Failures

- Initiated during 2007 IEEE PES GM:
  - *"To investigate new methods, technologies and tools in order to better understand, predict, mitigate and restore cascading failures. Sponsor technical sessions, tutorial courses, workshops, conferences for effective exchange of information on the state-of-the art, best practices, procedures and strategies."*
- Chair: Milorad Papic, IPC, USA

- 95 members:
  - Industry 29
  - Universities 44
  - National Labs 7
  - NERC 2
  - Vendors 7
  - EPRI 2
  - International industry members 4



IEEE CAMS TF on Cascading Failures – Drivers and Purpose

- Drivers:
  - Blackouts
  - NERC Standards
  - Limited commercially available Tools
- The purpose of TF is to facilitate the following activities:
  - Understanding of Cascading Failures
  - Prediction of Cascading Failures
  - Mitigation of Cascading Failures
  - Restoration from Cascading Failures
  - Availability of Tools for Analysis of Cascading Failures
  - Availability of Data for Analysis of Cascading Failures

TF Tasks

- Completed Tasks:
  - Task 1: Initial Review of methods for cascading analysis in electric power transmission systems, IEEE PES GM, Pittsburg, July 2008
  - Task 2: Vulnerability Assessment for Cascading Failures in Electric Power Systems, IEEE PSCE, Seattle, March 2009
  - Task 3: Risk Assessment Methodologies for Cascading Outages, IEEE PES GM, Detroit, July 2011
  - Task 4: Survey of Tools for Risk Assessment of Cascading Outages, IEEE PES GM, Detroit, July 2011
  - Task 5: Benchmarking of methodologies and tools for assessment of cascading outages, IEEE PES GM, San Diego, July 2012
- Present Tasks:
  - Mitigation and prevention of cascading outages
  - Benchmarking models and available data for cascading failure analysis

Definition of a Cascading Outage

- A cascading outage is a sequence of events in which an initial disturbance, or a set of disturbances, triggers a sequence of one or more dependent component outages:
  - In some cases they halt before the sequence results in the interruption of electricity service
  - In many case, cascading outages have resulted in massive disruptions to electricity service:
    - Northeast blackouts in 1965 and 2003, New York City blackout in 1977, two WECC blackouts in 1996, Brazil blackout in 2009, WECC blackout in 2011, etc.

Propagation of Cascading Outages

- Initiating events may include a wide variety of disturbances such as:
  - High winds
  - Lightning
  - Natural disasters
  - Contact between conductors and vegetation
  - Human error, etc.
- Many mechanisms cause subsequent outages can propagate beyond the initial outages
- Over 50% of blackouts involved many cascading elements and were “slow” in progression

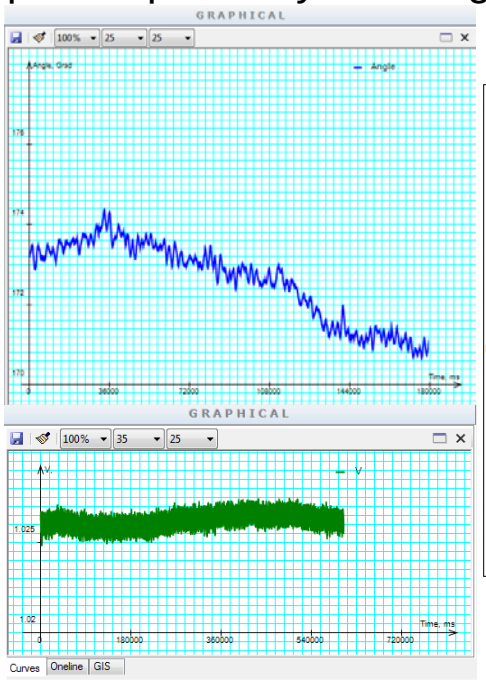
Why PMUs??

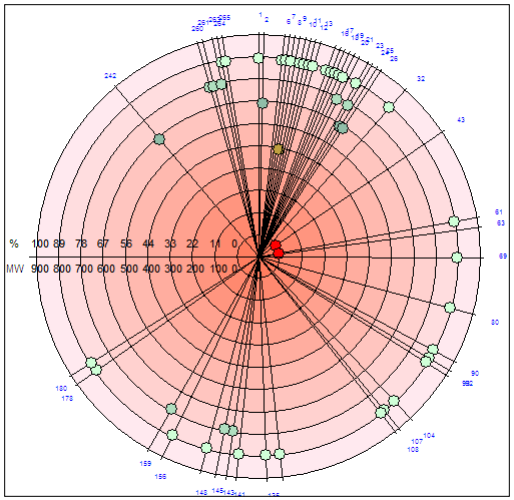
- PMUs are used for Wide Area Measurement Systems
- Functionalities to predict cascading outages include:
  - Early detection of events
    - Variations of reactive/active injections
    - Complements the information coming from breaker status signals
  - Voltage stability analysis on interfaces/corridors
    - Uses the V, I measurements at both ends of one line corridor and the maximum power transfer computation
    - Provides the voltage stability margin with respect to maximum transfer condition
  - Phase Angle Monitoring
    - Monitors high angle displacements, to detect highly loaded lines
  - Oscillatory analysis
    - Predicts unstable oscillations which may trigger line trippings

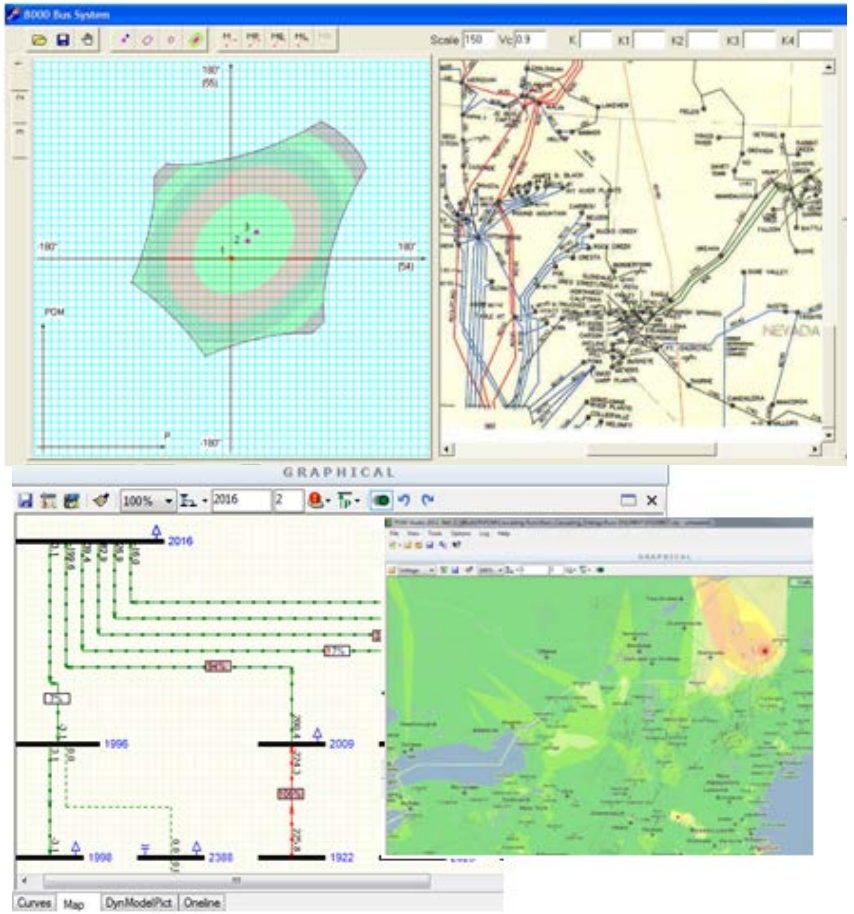
PMU Applications for Cascading Prediction: the US Experience

Phase angle and voltage monitoring

Using PMU measurements to compute system steady-state stability limits and predict proximity to voltage collapse







Source: M.Ya. Vaiman, M.M. Vaiman, S. Maslennikov, E. Litvinov, X. Luo, "Calculation and Visualization of a Power System Stability Margin Based on the PMU Measurements", 2010 IEEE SmartGridComm:31 - 36

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Use of PMUs for Analysis of Cascading Outages

- Prediction of “slow” cascading outages:
  - These cascades may be analyzed from steady-state stability perspective
- The most sensitive phase angles are identified in real-time for each scenario/interface/corridor:
  - These quantities are monitored, reported and visualized
  - May change over time as the system conditions change
- The accuracy of the limit values computed off-line may be improved by using real-time PMU measurements
  - These values are adjusted dynamically

Use of PMUs for Fast Identification/Prevention of Cascades

- PMU measurements allow for faster and more accurate relay operation and enabling ***RAS***
- Wide area oscillation ***damping control***
- Advanced defense functions, like ***coordinated*** wide area ***load shedding*** actions, ***controlled islanding***, etc
- No consolidated solutions so far

IEEE Papers Published by the TF

- Conference papers:
  - Initial review of methods for cascading failure analysis in electric power transmission systems, PES GM 2008.
  - Vulnerability Assessment for Predicting Cascading Failures in Electric Power Transmission Systems, PES GM 2009.
  - 2011GM0847 Risk Assessment of Cascading Outages: Part I - Overview of Methodologies, PES GM 2011.
  - 2011GM0803 Risk Assessment of Cascading Outages: Part II - Survey of Tools, PES GM 2011.
  - Mitigation and Prevention of Cascading Outages: Methodologies and Practical Applications (submitted for 2013 GM, Vancouver, Canada)
- IEEE Transactions on Power Systems:
  - Risk Assessment of Cascading Outages: Methodologies and Challenges, May 2012, Vol. 27, No. 2 pp. 631-641

Panel Session at PES GM 2013

- 2013 IEEE PES GM will be held July 21-25, 2013 in Vancouver, Canada.
- Panel Title
  - **Mitigation and Prevention of Cascading Outages: Methodologies and Practical Applications**
- Co-Chairs:
  - Milorad Papic (Idaho Power, mpapic@idahopowrer.com)
  - Paul Hines (University of Vermont, paul.hines@uvm.edu)
- IEEE Sponsors:
  - Computing and Analytical Methods Subcommittee (CAMS)
  - Risk, Reliability and Probability Applications (RRPA) Subcommittee
- Brief Abstract
  - The overall goal of this panel is to present state-of-the-art research and practical applications in the area of mitigation and prevention of cascading outage events in electric power systems. In response to recent large blackouts there is an increasing need to understand and mitigate blackout risk in electric power systems. This session will highlight the importance to further study mitigation and preventive actions as well as do future research in transforming data into actionable information to mitigate cascading blackout risk.

Agenda of 2013 Panel Session

- Section A
  - Milorad Papic (Idaho Power) and Robert Cummings (NERC) “Ex-post analysis of the blackout on 8 September 2011 in the US Southwest”
  - Anish Gaikwad (EPRI) and Sudhir Agarwal (General Reliability), “Ex-post analysis of the blackouts on 30 and 31 July 2012 in India”
  - Vladimir Terzija (The University of Manchester) “Ex-post analysis of the blackout on 4 November 2006 in Europe”
  - Jorge Jardim (HPPA, Brazil) “Ex-post analysis of the blackout on October 26 2012 in Brazil”
- Section B
  - Dmitry Kosterev (BPA), “Wide-Area Measurements in Prevention of Cascading Outages”

Agenda of 2013 Panel Session (cont)

- Section C
  - Marianna Vaiman (V&R Energy), “Mitigation and Prevention of Cascading Outages: Methodologies and Practical Applications”
  - Stephan Miller (CAI Inc.), “Benchmarking models and data for cascading failure analysis”
- Section D
  - Janusz Bialek (Durham University, UK), “Preventing Cascading Outages by Islanding”
  - Ian Dobson (Iowa State University), “Emerging approaches for simulating and analyzing cascading outages”
  - Paul Hines (University of Vermont), “Using Random Chemistry and Influence Graphs to Estimate Cascading Blackout Risk”

Conclusion

- If you haven't decided whether you should attend 2013 PES GM:
  - Participating at the CFTF Panel Session is a very sound reason!
- If you are planning to attend 2013 PES GM:
  - Please come to the session for a discussion on the analysis of cascading failures and use of PMUs to predict, prevent and analyze cascades.

Thank you!